

# Applied and Industrial Mathematics

## Undergraduate thesis topics

$$Eh \nabla^4 \varphi = \left( \frac{\partial^2}{\partial x^2} \frac{\partial^2}{\partial y^2} - 2 \frac{\partial^2}{\partial x \partial y} \frac{\partial^2}{\partial x \partial y} + \frac{\partial^2}{\partial y^2} \frac{\partial^2}{\partial x^2} \right) + \left( \frac{\partial^2}{\partial x^2} \frac{\partial^2}{\partial y^2} - \left( \frac{\partial x \partial y} \right) \right)$$

$$+ \frac{1}{Eh} \left( \frac{\partial^2 S_{xx}^e}{\partial y^2} - 2 \frac{\partial^2 S_{xy}^e}{\partial x \partial y} + \frac{\partial^2 S_{yy}^e}{\partial x^2} \right),$$

$$\nabla^4 w = P_{ext} + \left( \frac{\partial^2 w_0}{\partial x^2} \frac{\partial^2 \varphi}{\partial y^2} - 2 \frac{\partial^2 w_0}{\partial x \partial y} \frac{\partial^2 \varphi}{\partial x \partial y} + \frac{\partial^2 w_0}{\partial y^2} \frac{\partial^2 \varphi}{\partial x^2} \right) + \left( \frac{\partial^2 w}{\partial x^2} \frac{\partial^2 \varphi}{\partial y^2} - 2 \frac{\partial^2 w}{\partial x \partial y} \frac{\partial^2 \varphi}{\partial x \partial y} + \frac{\partial^2 w}{\partial y^2} \frac{\partial^2 \varphi}{\partial x^2} \right)$$

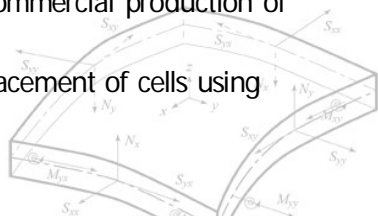
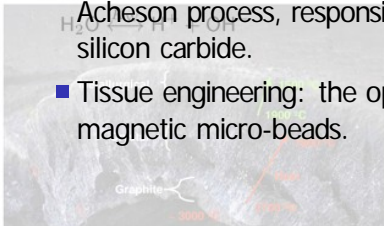
$$- \frac{1}{2(1-\nu)} \left( \frac{\partial^2}{\partial x^2} (M_{xx}^e - \nu M_{yy}^e) + 2(1-\nu) \frac{\partial^2}{\partial x \partial y} M_{xy}^e + \frac{\partial^2}{\partial y^2} (M_{yy}^e + \nu M_{xx}^e) \right) - \rho g h,$$

C. Sean Bohun (possible topics: 1 of 2)



- Predicting and prescribing distortion of thin glass sheets.
- Investigate complex chemical processes. Examples include: the carbonate system, responsible for ocean acidification; the Acheson process, responsible for commercial production of silicon carbide.

- Tissue engineering: the optimal placement of cells using magnetic micro-beads.





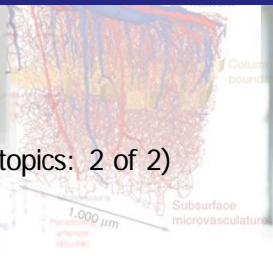
## C. Sean Bohun (possible topics: 2 of 2)



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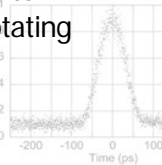
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■ Modelling processes that characterize unknown samples to increase their current capabilities. Examples include: rotating disk apparatus, high resolution melt analysis and cyclic voltammetry.

■ Develop mathematical tools to help design high power tuneable lasers.

■ Model biological processes. Examples include: brain vascular systems and bone remodelling.



$$G[A] = -\frac{A}{\sqrt{W_0}} \sqrt{aEe^E}, \quad E = \int_{-\infty}^{\infty} |A|^2 dt$$

$$M[A] = A \left[ \frac{1}{2} - \frac{v}{2} \cos(\mu\pi e^{-T^2}) \right], \quad F[A] = Ae^{ib|A|^2},$$

$$D[A] = \frac{\sigma e^{i\pi/4}}{\sqrt{\pi}} \int_{-\infty}^{\infty} A(\tau) e^{-i\sigma^2(\tau-T)^2} d\tau, \quad L[A] = Ah.$$



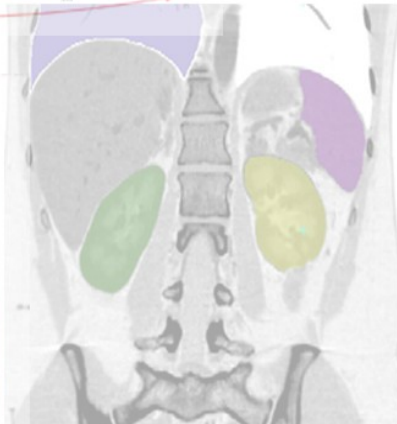
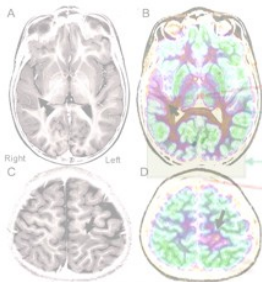
Jane Breen (possible topics)

- Clustering algorithms in directed networks (with applications to road traffic dynamics)
- Kemeny's constant and graph connectivity
- Sensitivity analysis of Markov chain models

$$\bar{E}(h) = \sum_{j=1}^n m(F_j) \max_{x \in F_j} h(x)$$

$$\frac{n-1}{2} < K(P) \leq \frac{n-1}{1-\lambda_2}$$

$$-1 < \lambda_n < \lambda_{n-1} < \dots < \lambda_2 < \lambda_1 = 1$$



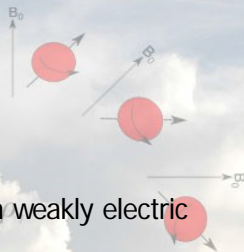
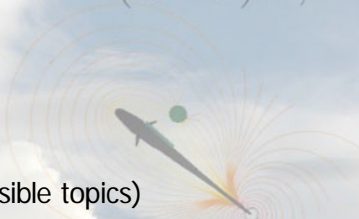
Mehran Ebrahimi (possible topics)

- Medical image registration
- Medical image segmentation
- Medical image fusion

$$\frac{\partial \mathbf{u}}{\partial t} = \nu \nabla^2 \mathbf{u} - 2\boldsymbol{\Omega} \times \mathbf{u} + (g\mathbf{e}_z - \nabla \Pi)$$

$$\frac{\partial T}{\partial t} = \kappa \nabla^2 T - (\mathbf{u} \cdot \nabla) T,$$

$$\nabla \cdot \mathbf{u} = 0$$



### Greg Lewis (possible topics)

- Transitions in atmospheric flow patterns
- Mathematical models for electro-location in weakly electric fish
- Mathematical aspects of MRI

$$\nabla \cdot \mathbf{B} = 0,$$

$$\nabla \times \mathbf{E} = -i\omega \mathbf{B},$$

$$\nabla \times \mathbf{B} = \mu((\sigma + i\omega\epsilon) \mathbf{E} + \mathbf{j}_e)$$



Lennaert van Veen (possible topics)

NOTE: Dr. van Veen is on sabbatical in 2021/2022

- Phase transition in interface formation. Will include elements of: theory of interface formation, stochastic partial differential equations, numerical methods, data analysis.
- Bi-stability and critical noise. Includes: "flickering" noise in dynamical systems, the telegraph process, simple simulations.
- Stability analysis of shear flows. Will include elements of: Navier-Stokes flow, energy methods, Squire's theorem, Orr-Sommefeld equations.

